

Exploring Symbiosis

By Josh Lord

Abstract

Students participate in a game to understand the meanings of different types of symbiosis. Children discover the meaning and importance of symbiosis by matching hosts and symbionts based on their respective needs. Symbiosis is an excellent example of the interconnectivity between different plants and animals and their environments.

Most relationships between plants and animals are viewed as unidirectional, as in the model of a food chain where an herbivore eats plants and carnivores eat herbivores. However, many relationships between organisms are more complex and involve multidirectional interactions. In symbiosis, for example, two dissimilar organisms are closely associated with each other, with at least one organism receiving unique benefits from the relationship. One organism has evolved to use the other as a unique habitat or niche that it can exploit to gain a competitive advantage. There are three general types of symbiosis: mutualism, commensalism, and parasitism. Based on the nature of the interaction between organisms, symbiotic relationships are loosely grouped into one of these types.

Types of Symbiosis

Mutualism is a mutually beneficial relationship in which both organisms benefit. Each individual provides an advantage to the other, enabling them to exploit each other and thereby enhance their chances of survival. An example is the anemone-clownfish mutualism, in which the clownfish gets food scraps from the anemone and uses the stinging cells of the anemone for protection. The anemone gets smothering algal cover cleaned off by the clownfish and absorbs nutrients from the clownfish's nitrogenous waste, so both organisms benefit. Another well-known example of mutualism is the relationship between corals and zooxanthellae, a type of algae that live in corals. The coral gets extra nutrition from the algae as it photosynthesizes, and the zooxanthellae are protected by the hard coral and obtain plant nutrients from the coral (e.g., ammonia).



Clownfish hiding in a sea anemone¹

Commensalism is loosely defined as a symbiotic relationship in which one organism benefits and the other is unaffected. For example, burdock plants produce seed heads called burs that are covered in hooks. The hooks catch in the fur of passing mammals, where they are carried until they fall off. This provides the burdock plant with an effective seed dispersal mechanism, while the mammal is unaffected. Another example of a commensal relationship exists between cattle egrets and cattle. As cattle or other large mammals graze they stir up insects, which are the prey of the cattle egret. The impact of the cattle egret on cattle or other large mammals is minimal.

Parasitism is a relationship that is beneficial for one organism and harmful for the other. A tapeworm is a parasite that gains an advantage by hurting another organism, its host. In this case the parasite feeds on digested material in the intestines, taking nutrition away from the host; the parasite has evolved to capitalize on a previously unexploited habitat, to the detriment of the host. Another example is mistletoe, which is a type of plant that parasitizes trees. The roots of the mistletoe penetrate the bark, capturing nutrients from the tree.

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Exploring Symbiosis:

How does it impact different organisms?

Objectives:

Discover which plants and animals have symbiotic relationships and how this impacts each organism. Explore the advantages and disadvantages of different types of symbiosis.

Process Skills:

Communicating, Comparing, Contrasting, Classifying

Grade Level: 4-6

Before the Lesson:

Make an overhead, poster, or computer slideshow of examples of mutualism, commensalism and parasitism. Make enough cards for the whole class (note cards or laminated paper), each card with an organism on it. Each card should list one or two things that this organism needs and that it can provide. For example, a mutualism card could say that coral need nutrients and that they provide a hard, protected place to live. An example card pair is shown later in the article and many cards are available at the web link below. There should be an equal number of card pairs for mutualism, commensalism, and parasitism. This lesson can either focus on just marine symbiotic relationships or on a variety of symbioses. Many examples of symbiotic relationship cards are provided at the end of this lesson and are available online.

This lesson goes more easily if it follows a lesson on food webs, where students learn how different organisms are connected. By teaching a food web lesson prior to this one, students would already have some understanding of the complex relationships between organisms. As a result, this symbiosis lesson could build on their previous ideas of close interactions and interconnectivity between organisms. An example of a food web lesson is posted at <http://www.uoregon.edu/~oimb/Academics/GK12/fourthgrade.html>.

Exploration:

Ask the students if they can think of any close relationships between organisms and write their ideas on the board. Our unit was on kelp forests so students mentioned relationships between kelp, sea urchins, sea stars, and fish. If they have difficulty with the question, ask “are there some animals that live near or on other animals?” and “do you think they interact with each other?” When we taught this lesson these questions sparked many suggestions from the students, and providing an example definitely started the ball rolling.

Since the terms for this lesson are likely unfamiliar to the students, quickly shift towards defining symbiosis and the different types of symbiotic relationships. Start with a familiar example such as “has anyone ever heard of mistletoe?” Most of our students had, though not in the context of symbiosis. Explain that mistletoe is actually what is called a parasite because it takes its nutrition from another organism, but without killing it. Symbiotic relationships (write down) are between organisms that are not similar but are closely associated with each other. Note that at least one organism gets a unique benefit from this close interaction. Explain that commensalism can be defined as “when one of the organisms is helped, but it has no impact on the other organism,” such as the relationship between a deer and a burdock. The burdock seed (bur) is carried away from the parent plant and the deer or other animal is unaffected. Mutualism is “when both organisms get something out of the relationship,” such as with a sea anemone and clownfish.

Mutualists can be described as “teammates,” commensalists as “neighbors,” and parasites as “thieves.” The more examples the better, so that students can begin to understand the different types of symbiosis. Make sure all four terms are written on the board (symbiosis, mutualism, commensalism, parasitism) and emphasize that they are big, cool words. Examples that are discussed can be written underneath each of the three different types of symbiosis. At this point, it is not necessary that all the students have a complete understanding of each term, since that is the point of the game.

Materials

For the whole class (class of 30):

- Poster, overhead, or PowerPoint presentation of different symbiotic relationships
- 5 pairs of cards of two organisms with a mutualistic relationship (Figure 1) (each card has one organism)
- 5 pairs of cards of two organisms with a parasitic relationship (Figure 1) (each card has one organism)
- 5 pairs of cards of two organisms with a commensal relationship (Figure 1) (each card has one organism)

Procedure:

1. Divide the class into three groups with even numbers of students, giving each group a name (mutualism, commensalism, parasitism). Explain to each group which type of symbiosis they are and what that means. Tell the mutualism group that both organisms must benefit from the relationships on the cards that they will receive. Explain to the commensalism group that one organism will benefit and the other will be unaffected, and tell the parasitism group that one organism will be hurt while the other benefits in that kind of relationship. Within each group, shuffle and hand out the cards that correspond with that group (parasitism group gets parasite cards, etc.) Make sure that all paired cards are passed out within a group, so each parasite has a corresponding host. Paired cards are available at the end of this article, although there are many other examples that could be used to teach this lesson.
2. Tell the class that each student has someone in their group that has a symbiotic relationship with them. Explain that one organism is using the other as a unique habitat in order to feed, survive, and reproduce. They are going to try to find their “symbiont” by talking to other group members about what each organism has and needs.
3. Once a pair of students has figured out that they share a symbiotic relationship (5-10 minutes), have them come up and check that the pairing is correct (if not, send them back to the group).
4. If students are right, have them write their two organisms together on the board with a circle around them. The whole class should write with the same color marker and there should be no organization on the board with regard to group or type of symbiosis.
5. Once all the pairs of organisms are written on the board, explain that students will be working in pairs to guess what kind of symbiotic relationship the organisms on the board have. Read off the cards for each pair of organisms, and if students guess correctly and explain their answer (mutualism, commensalism, parasitism) they will get points for their group. One pair of students from each group will answer at a time. An incorrect guess will be turned over to the rest of the class to answer, but not for points. Students should not be asked about relationships they wrote on the board themselves.
6. Explain the points system. If students correctly answer mutualism, their group receives 3 points and the other groups receive one because mutualism helps everyone. If students correctly answer commensalism, their group gets two points and the other groups get none because it only helps one organism. If parasitism is the correct answer, they get one point but the other groups lose a point. Ask the groups how many points they get and why for each answer. When we did this, it helped with students’ understanding of the different types of symbiosis and they were excited about the variety of scoring options.

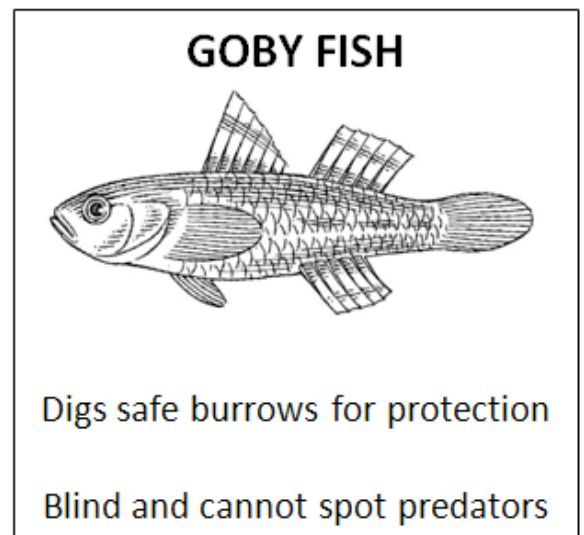
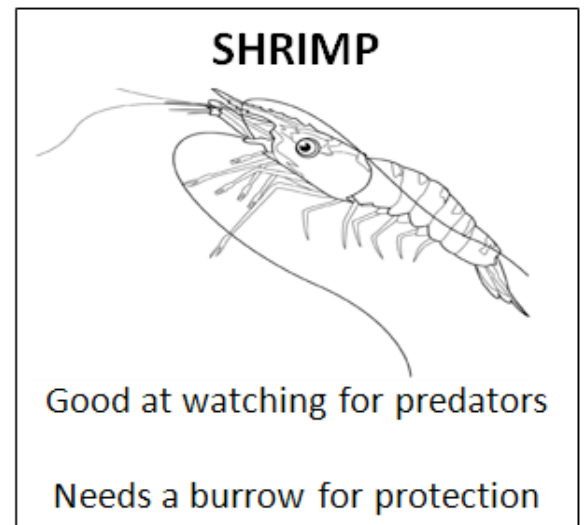


Figure 1. Example of a pair of symbiosis cards (mutualism).

Discussion:

By the end of the game, students should have a good understanding of what makes a relationship parasitic, commensal, or mutualistic. This can be reinforced by asking the class to explain what each term means. Have them explain the points system—why would the other groups lose points with parasitism or get points with mutualism? In our classes, this sparked a discussion of the costs and benefits of symbiosis. Ask questions like “why would a plant or animal want to be in a mutualistic relationship?” or “why would it benefit an organism to be parasitic?” Asking these questions helped our classes to bring together the information that they had learned from this lesson, and their depth of understanding was remarkable. When summarizing symbiosis, make sure it is clear that organisms in symbiotic relationships have evolved to exploit a unique habitat that another organism provides. These relationships are not based on organisms helping one another but rather on the advantages that can be gained by finding and using a previously unexploited niche.

A good way to wrap up the lesson is to ask about other examples that were not used in the game. These could be actual relationships or ones that you make up. For example, “if an alien has a lot of extra food and an itchy back and there is an animal that scratches backs but is bad at finding food, what kind of relationship could develop?” Examples like this excited the class and sparked them to try to come up with their own examples. There are an abundance of symbiotic relationships that exist in nature.

Assessment:

Have students divide a sheet of paper into three columns and head each column with a type of symbiosis (mutualism, commensalism, parasitism). They can then put all the pairs of organisms on the board into one of the categories. Discuss the impacts on both organisms for each of the different types of symbiosis. The impacts on both organisms can be denoted with $+/+$, $+/0$, and $+/-$ for each symbiosis type. These follow-up exercises help drive home the main points, but even without these, students grasped the concept of symbiosis. This lesson kept them engaged for 45 minutes, aided by the game atmosphere.

Adaptation for Older Students:

Older or more advanced students can write down definitions of each type of symbiosis and/or give a brief explanation why each pair of organisms from the board should be in the category in which they were placed. They could also be creative and make up an example for each type of symbiosis.

Connecting to the Standards:

National Science Education Content Standards - Life Science Standard

Elementary

- Characteristics of organisms
- Organisms and environments

Middle School

- Populations and ecosystems
- Diversity and adaptations of organisms

High School

- Interdependence of organisms
- Behavior of organisms
- Biological evolution

Ocean Literacy Essential Principles and Fundamental Concepts²:

Principle 5: The ocean supports a great diversity of life and ecosystems

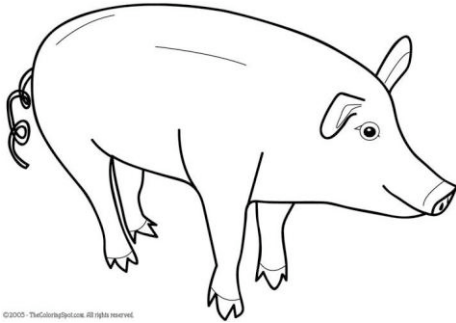
Concept D: Ocean biology provides many unique examples of life cycles, adaptations and important relationships among organisms (symbiosis, predator-prey dynamics and energy transfer) that do not occur on land

¹ http://farm2.static.flickr.com/1049/1004710143_54bd55e715.jpg?v=0

² National Geographic Society. (2007). *Ocean Literacy Principles* [brochure].

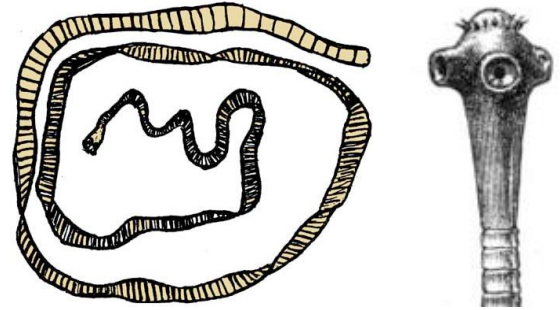
Parasitism Examples

PIG



Have lots of digested food in the intestine

TAPEWORM



Need to eat food that is already digested

MISTLETOE



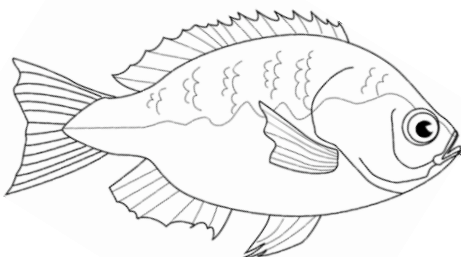
Type of plant that sucks nutrients out of trees

OAK TREE



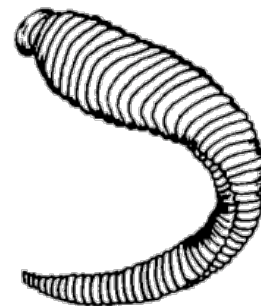
Big tree with lots of nutrients

FISH



Live in the water and have blood

LEECH



Live in the water and suck blood from animals that live in water

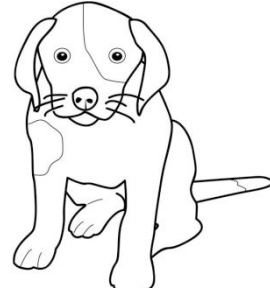
Parasitism Examples

TICK



Lives in the grass and needs to attach to an animal and eat blood

DOG



Animal that runs through the grass and has blood

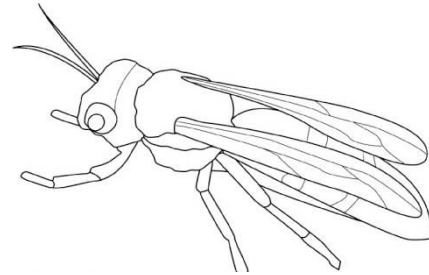


CATERPILLAR



Eats leaves on trees and other plants

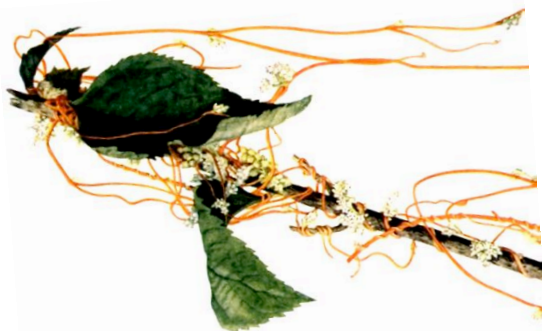
EUCHARITID WASP



Lay eggs inside a caterpillar

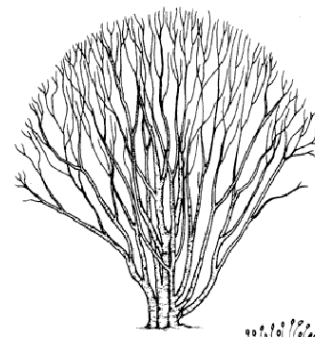


DODDER



Vine that wraps around a plant and takes nutrients and water from it

SHRUBS

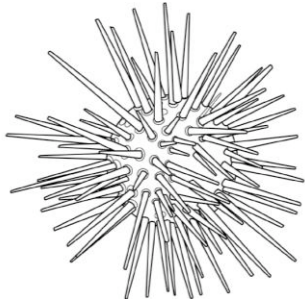


Get water and nutrients from the ground and nutrients from the sun



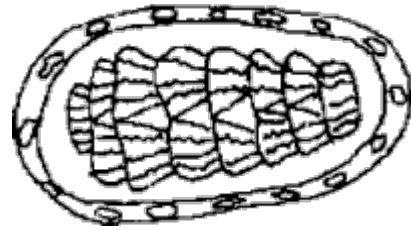
Commensalism Examples

PURPLE SEA URCHIN



Make burrows in the rock for protection

LINED CHITON



Need a burrow for protection from predators and waves

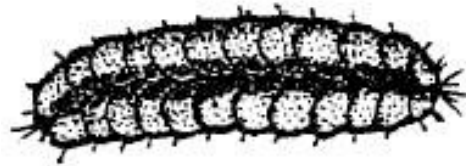


GUMBOOT CHITON



Have large openings under their gills

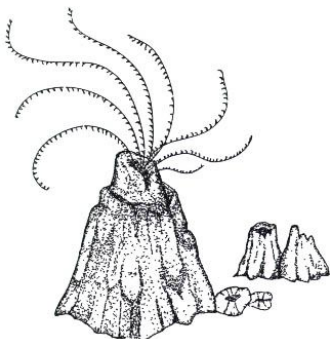
SCALE WORM



Need an ocean animal to live in for protection and water flow

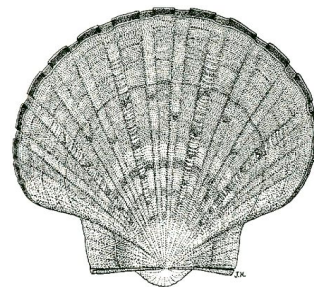


BARNACLE



Needs a hard, flat, open surface to attach to and live on

SCALLOP

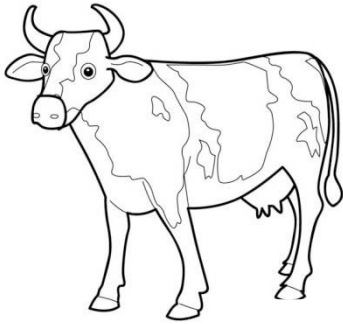


Makes a hard, flat shell



Commensalism Examples

COWS



Graze in a herd in open fields

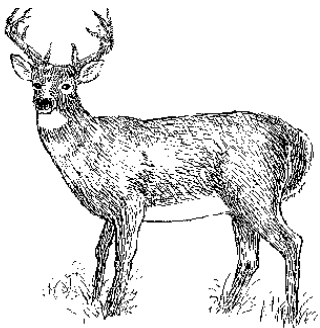
CATTLE EGRET



Eat insects that get stirred up by large herds of animals



DEER



Moves around a lot through forests and fields

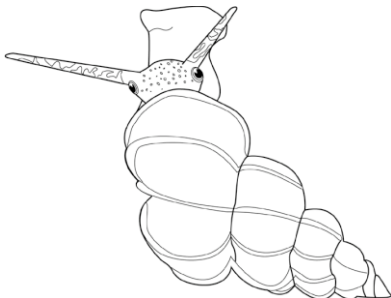
BURDOCK



Has sticky burs that need to be carried around to make new burdock plants

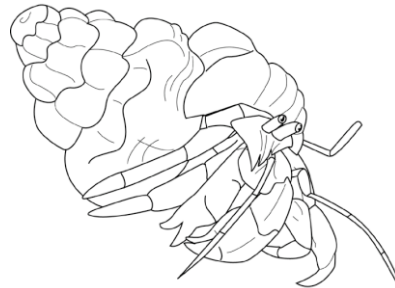


SEA SNAIL



Makes hard, round shells to live in for protections

HERMIT CRAB

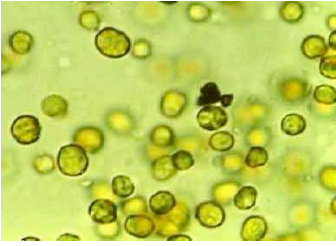


Uses shells made by other animals for protection



Mutualism Examples

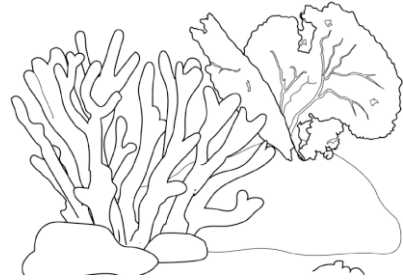
ZOOXANTHELLAE (algae)



Produces extra nutrients

Needs a hard place to live for protection

CORAL REEF

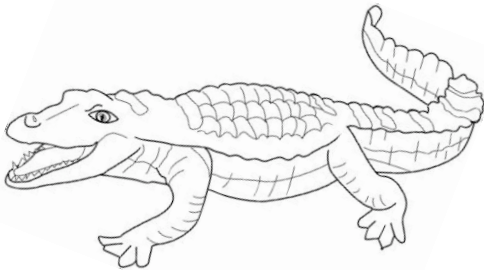


Provides a hard place to live

Needs nutrients to grow faster



NILE CROCODILE



Has leeches in its mouth

Needs to get rid of leeches in its mouth

EGYPTIAN PLOVER

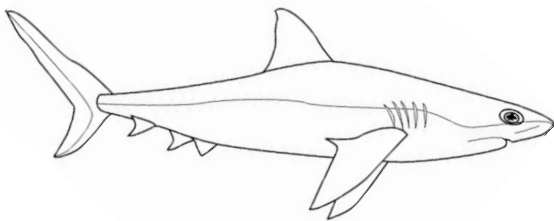


Eats leeches

Needs to find a reliable source for leeches to eat



SHARK



Has food scraps and parasites in its mouth

Needs to get rid of parasites

CLEANER FISH



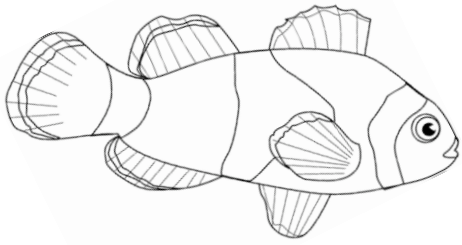
Eats food scraps and parasites

Needs to find food scraps and parasites to eat



Mutualism Examples

CLOWNFISH



Excretes nutritional waste and eats algae

Needs a place to hide and be protected



SEA ANEMONE



Has stinging tentacles

Needs nutrients and protection from competition with algae

SEA ANEMONE

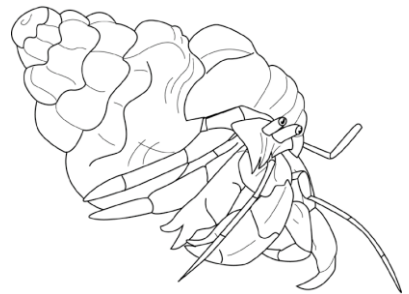


Has stinging tentacles

Needs water flow to feed



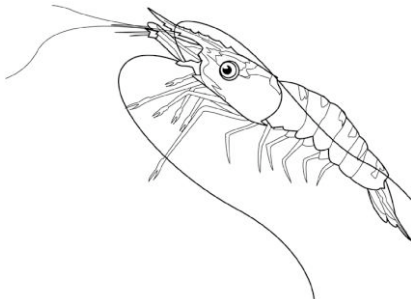
HERMIT CRAB



Moves around a lot

Needs protection from predators

SHRIMP

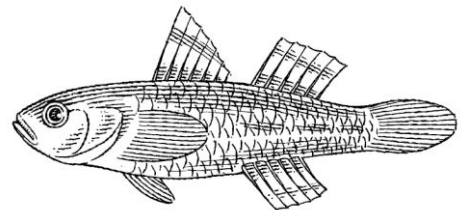


Good at watching for predators

Needs a burrow for protection



GOBY FISH



Digs safe burrows for protection

Blind and cannot spot predators

Card Illustration Credits

Pig, Fish, Dog, Wasp, Urchin, Cow, Sea Snail, Hermit Crab, Anemone, Shark, Coral, Crocodile, Clownfish, Shrimp, Goby Fish

<http://www.thecoloringspot.com>

Tapeworm

<http://www.saburchill.com/ans02/chapters/chap014.html>

Mistletoe

http://www.istockphoto.com/file_closeup/special_days_holidays_and_festivals/christmas/mistletoe/2436739-oak-mistletoe-phoradendron-villosum.php?id=2436739

Oak Tree

<http://www.inkart.com/pages/ColorSamples/tree.html>

Leech

<http://www.bcadventure.com/adventure/angling/bugs/leech/leech.phtml>

Tick

http://www.usbr.gov/mp/ccao/field_offices/new_melones/wildlife.html

Caterpillar

<http://www.aragriculture.org/insects/soybean/default.htm>

Dodder

<http://www.swsbm.com/HOMEPAGE/NameIndexDL.html>

Shrub

<http://www.tlwp.com.au/images/willow.gif>

Egyptian Plover

<http://www.birdfinders.co.uk/tours/gambia.htm>

Cleanerfish

http://animaldiversity.ummz.umich.edu/site/resources/Grzimek_fish/Labroidei/LabroideiII/Labroides_dimidatus.jpg/view.html

Zooxanthellae

<http://oceanworld.tamu.edu/students/coral/coral3.htm>

Deer

<http://www.extension.umn.edu/yardandgarden/ygbriefs/images/horticulture/linedrawings/deer.gif>

Scallop

http://www.dpi.nsw.gov.au/_data/assets/image/0016/119140/scallop.jpg

Barnacle

http://www.earthseaspacemuseum.org/img/activities_ocean_img/barnacle.jpg

Lined Chiton

<http://www.wavelengthmagazine.com/1999/am99neigh.html>

Burdock

<http://dailyrenew.com/about2.html>

Cattle Egret

<http://www.cs.albany.edu/~mosh/Birds/>

Gumboot Chiton

<http://www.todomarino.com/forum/showthread.php?t=12586>

Scaleworm

<http://www.glf.dfo-mpo.gc.ca/os/bysea-enmer/shores-rivages-e.php>